

**WHAT IS CLAIMED IS:**

- 1        1. A method of determining scalefactors used to encode a signal, comprising the steps  
2        of:  
3              associating a plurality of distortion thresholds, respectively, with a plurality of  
4              frequency scalefactor bands of the signal;  
5              transforming the signal to yield a plurality of sets of transform coefficients, one set for  
6              each of the frequency scalefactor bands; and  
7              calculating a plurality of total scaling values, one for each of the frequency scalefactor  
8              bands, such that an anticipated distortion based on the product of a transform  
9              coefficient for a given scalefactor band with its respective total scaling value is  
10             less than a corresponding one of the distortion thresholds.
- 1        2. The method of Claim 1 wherein the signal is a digital signal, and further  
2        comprising the step of converting an analog signal to the digital signal.
- 1        3. The method of Claim 1 wherein said associating step uses distortion thresholds  
2        which are based on psychoacoustic masking.
- 1        4. The method of Claim 1 wherein said calculating step includes the steps of:  
2              for a given frequency scalefactor band, obtaining a first term based on a  
3              corresponding distortion threshold; and  
4              obtaining a second term based on a sum of the transform coefficients
- 1        5. The method of Claim 4 wherein:  
2              the first term is obtained from a first lookup table; and  
3              the second term is obtained from a second lookup table.
- 1        6. The method of Claim 1 wherein a given total scaling value  $A_{sfb}$  for a particular  
2        frequency scalefactor band is calculated according to the equation:  
3              
$$A_{sfb} = 2[4/(9BW_{sfb})]^{2/3} * (1/M_{sfb})^{2/3} * (\sum x_i)^{1/3},$$

4 where  $BW_{sf_b}$  is the bandwidth of the particular frequency scalefactor band,  $M_{sf_b}$  is the  
5 corresponding distortion threshold, and  $\sum x_i$  is the sum of all of the transform  
6 coefficients for the particular scalefactor band.

1 7. The method of Claim 1, further comprising the steps of:  
2 identifying one of the total scaling values as a minimum nonzero value; and  
3 normalizing at least one of the total scaling values using the minimum nonzero value,  
4 to yield a respective plurality of scalefactors, one for each scalefactor band.

1 8. The method of Claim 7, further comprising the steps of:  
2 setting a global gain factor to the minimum nonzero value; and  
3 re-quantizing the transform coefficients using the global gain factor and the  
4 scalefactors.

1 9. The method of Claim 8, further comprising the steps of:  
2 computing a number of bits required for said quantizing step; and  
3 comparing the number of required bits to a predetermined number of available bits.

1 10. The method of Claim 9 wherein said comparing step establishes that the number  
2 of required bits is greater than the predetermined number of available bits, and further  
3 comprising the steps of:  
4 reducing the global gain factor; and  
5 quantizing the transform coefficients using the reduced global gain factor and the  
6 scalefactors.

1 11. A method of encoding an audio signal, comprising the steps of:  
2 identifying a plurality of frequency scalefactor bands of the audio signal;  
3 associating a plurality of distortion thresholds, respectively, with the plurality of  
4 frequency scalefactor bands of the audio signal, the distortion levels being  
5 based on a psychoacoustic mask;  
6 transforming the audio signal to yield a plurality of transform coefficients, one for  
7 each of the frequency scalefactor bands;

8 calculating a plurality of total scaling values, one for each of the frequency scalefactor  
9 bands, based on the distortion thresholds and the transform coefficients;  
10 normalizing at least one of the total scaling values using a minimum nonzero one of  
11 the total scaling values, to yield a respective plurality of scalefactors, one for  
12 each scalefactor band;  
13 setting a global gain factor to the minimum nonzero total scaling value;  
14 quantizing the transform coefficients using the global gain factor and the scalefactors,  
15 to yield an output bit stream;  
16 computing a number of bits required from said quantizing step;  
17 comparing the number of required bits to a predetermined number of available bits;  
18 and  
19 packing the output bit stream into a frame.

1 12. The method of Claim 11 wherein said calculating step includes the step of  
2 obtaining a term from a lookup table based on a corresponding distortion threshold.

1 13. The method of Claim 11 wherein said calculating step includes the step of  
2 obtaining a term from a lookup table based on a sum of the transform coefficients.

1 14. The method of Claim 11 wherein a given total scaling value  $A_{sf_b}$  for a particular  
2 frequency scalefactor band is calculated according to the equation:

$$3 A_{sf_b} = 2[4/(9BW_{sf_b})]^{2/3} * (1/M_{sf_b})^{2/3} * (\sum x_i)^{1/3},$$

4 where  $BW_{sf_b}$  is the bandwidth of the particular frequency scalefactor band,  $M_{sf_b}$  is the  
5 corresponding distortion threshold, and  $\sum x_i$  is the sum of all of the transform  
6 coefficients for the particular scalefactor band.

1 15. A device for encoding a signal, comprising:  
2 means for associating a plurality of distortion thresholds, respectively, with a plurality  
3 of frequency scalefactor bands of the signal;  
4 means for transforming the signal to yield a plurality of transform coefficients, one for  
5 each of the frequency scalefactor bands; and

6 means for calculating a plurality of total scaling values, one for each of the frequency  
7 scalefactor bands, such that an anticipated distortion based on the product of a  
8 transform coefficient for a given scalefactor band with its respective total  
9 scaling value is less than a corresponding one of the distortion thresholds.

1 16. The device of Claim 15 wherein a given total scaling value  $A_{sf_b}$  for a particular  
2 frequency scalefactor band is calculated according to the equation:

$$3 A_{sf_b} = 2[4/(9BW_{sf_b})]^{2/3} * (1/M_{sf_b})^{2/3} * (\sum x_i)^{1/3},$$

4 where  $BW_{sf_b}$  is the bandwidth of the particular frequency scalefactor band,  $M_{sf_b}$  is the  
5 corresponding distortion threshold, and  $\sum x_i$  is the sum of all of the transform  
6 coefficients for the particular scalefactor band.

1 17. The device of Claim 15, further comprising means for normalizing at least one of  
2 the total scaling values using a minimum nonzero one of the total scaling values, to yield a  
3 respective plurality of scalefactors, one for each scalefactor band.

1 18. An audio encoder comprising:  
2 an input for receiving an audio signal;  
3 a psychoacoustic mask providing a plurality of distortion thresholds, respectively, for  
4 a plurality of frequency scalefactor bands of the audio signal;  
5 a frequency transform which operates on the audio signal to yield a plurality of  
6 transform coefficients, one for each of the frequency scalefactor bands; and  
7 a quantizer which calculates a plurality of total scaling values, one for each of the  
8 frequency scalefactor bands, such that an anticipated distortion based on the  
9 product of a transform coefficient for a given scalefactor band with its  
10 respective total scaling value is less than a corresponding one of the distortion  
11 thresholds.

1 19. The audio encoder of Claim 18 wherein, for calculation of a total scaling value  
2 for a given frequency scalefactor band, said quantizer obtains a first term based on a  
3 corresponding distortion threshold, and obtains a second term based on a sum of the  
4 transform coefficients.

1        20. The audio encoder of Claim 18 wherein:

2              the first term is obtained from a first lookup table; and  
3              the second term is obtained from a second lookup table.

1        21. The audio encoder of Claim 18 wherein a given total scaling value  $A_{sf_b}$  for a  
2 particular frequency scalefactor band is calculated according to the equation:

3              
$$A_{sf_b} = 2[4/(9BW_{sf_b})]^{2/3} * (1/M_{sf_b})^{2/3} * (\sum x_i)^{1/3},$$

4              where  $BW_{sf_b}$  is the bandwidth of the particular frequency scalefactor band,  $M_{sf_b}$  is the  
5              corresponding distortion threshold, and  $\sum x_i$  is the sum of all of the transform  
6              coefficients for the particular scalefactor band.

1        22. The audio encoder of Claim 18 wherein said quantizer normalizes all of the total  
2 scaling values using a minimum nonzero one of the total scaling values, to yield a respective  
3 plurality of scalefactors, one for each scalefactor band.

1        23. The audio encoder of Claim 22 wherein said quantizer sets a global gain factor to  
2 the minimum nonzero value, and quantizes the transform coefficients using the global gain  
3 factor and the scalefactors.

1        24. The audio encoder of Claim 23 wherein said quantizer further compares a number  
2 of bits required for said quantizing step to a predetermined number of available bits.

1        25. The audio encoder of Claim 24 wherein said quantizer further reduces the global  
2 gain factor and quantizes the transform coefficients using the reduced global gain factor and  
3 the scalefactors, in response to a determination that the number of required bits is greater than  
4 the predetermined number of available bits.

1        26. A computer program product comprising:  
2              a computer-readable storage medium; and  
3              program instructions stored on said storage medium for calculating a plurality of total  
4              scaling values associated with different frequency scalefactor bands of a

5 signal, using transform coefficients of the signal and distortion thresholds for  
6 each frequency scalefactor band, such that the product of a transform  
7 coefficient for a given scalefactor band with its respective total scaling value is  
8 less than a corresponding one of the distortion thresholds.

1 27. The computer program product of Claim 26 wherein said program instructions  
2 further carry out a frequency transform of the signal to yield the transform coefficients.

1 28. The computer program product of Claim 26 wherein said program instructions  
2 further provide the distortion thresholds based on a psychoacoustic mask.

1 29. The computer program product of Claim 26 wherein said program instructions  
2 calculate a total scaling value for a given frequency scalefactor band by obtaining a first term  
3 based on a corresponding distortion threshold, and obtaining a second term based on a sum of  
4 the transform coefficients.

1 30. The computer program product of Claim 29 wherein said program instructions  
2 obtain the first term from a first lookup table, and obtain the second term from a second  
3 lookup table.

1 31. The computer program product of Claim 26 wherein said program instructions  
2 calculate a given total scaling value  $A_{sf_b}$  for a particular frequency scalefactor band according  
3 to the equation:

4 
$$A_{sf_b} = 2[4/(9BW_{sf_b})]^{2/3} * (1/M_{sf_b})^{2/3} * (\sum x_i)^{1/3},$$

5 where  $BW_{sf_b}$  is the bandwidth of the particular frequency scalefactor band,  $M_{sf_b}$  is the  
6 corresponding distortion threshold, and  $\sum x_i$  is the sum of all of the transform  
7 coefficients for the particular scalefactor band.

1 32. The computer program product of Claim 26 wherein said program instructions  
2 further identify one of the total scaling values as a minimum nonzero value, and normalize all  
3 of the total scaling values using the minimum nonzero value, to yield a respective plurality of  
4 scalefactors, one for each scalefactor band.

1       33. The computer program product of Claim 32 wherein said program instructions  
2 further set a global gain factor to the minimum nonzero value, and quantize the transform  
3 coefficients using the global gain factor and the scalefactors.

1       34. The computer program product of Claim 33 wherein said program instructions  
2 further compute a number of bits required for said quantizing, and compare the number of  
3 required bits to a predetermined number of available bits.

1       35. The computer program product of Claim 34 wherein said comparing establishes  
2 that the number of required bits is greater than the predetermined number of available bits,  
3 and said program instructions further reduce the global gain factor, and quantize the  
4 transform coefficients using the reduced global gain factor and the scalefactors.